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# The Effect of Mortgage Payment Reduction on Default: Evidence from the Home Affordable Refinance Program

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# Disclaimers

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The views expressed here are those of the authors and do not represent the views of Freddie Mac, its Board of Directors, the Federal Housing and Finance Administration (FHFA), the Urban Institute, its trustees, or its funders.

# Summary

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- Finding: Among borrowers refinancing within the Home Affordable Refinance Program (HARP), a 10% reduction in monthly payments leads to about a 10%-12% reduction in monthly default hazard
- Result holds when controlling for program participation based on observables
- Contributions:
  - Extend literature on payment shocks and default from smaller market segments to mainstream fixed-rate 30-year mortgage market
  - Controls for selection based on observables using novel approach from biostatistics literature

# Road Map

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- HARP program description
- Literature review
- Data description and summary statistics
- Hazard model estimates
- 2-stage selection and hazard model estimates
- Wrap up

# Motivation

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- What is HARP? From August 2013 FHFA Refinance Report (p. 1)\*:
  - “HARP was established in 2009 to assist homeowners unable to access a refinance due to a decline in their home value... The program is designed to provide these borrowers with an opportunity to refinance by permitting the transfer of existing mortgage insurance to their newly refinanced loan, or by allowing those without mortgage insurance on their previous loan to refinance without obtaining new coverage.”
  - As of August 2013, 2.89 million borrowers refinanced through HARP program with Fannie Mae and Freddie Mac
  - Scheduled to expire December 31, 2015
  - Many borrowers refinance into mortgage with lower rates, reducing their monthly principal & interest (P&I) payment
- Natural experiment to analyze the effect of this payment reduction on default
  - Large population of conforming mortgages
  - Material payment reductions

\*<http://www.fhfa.gov/webfiles/25620/August2013RefiReport.pdf>

# HARP Program Requirements for Freddie Mac Borrowers

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- Initial program requirements for “HARP 1” (June 2009 – December 2011)
  - Estimated current LTV above 80% and less than or equal to 125%
  - Current on payment history for prior 12 months
- Expansion to “HARP 2” relaxing requirements (January 2012 – present)
  - No upper bound on current LTV (e.g. loans above 125%)
  - Current on payment history for prior 12 months or at most a single missed payment 7 to 12 months prior
- Subtle differences in eligibility for Fannie Mae

# Literature Review

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- Zhu (2012) - HARP program treatment effect
- Payment reduction
  - Fuster and Willen (2012)
  - Tracy and Wright (2012)
- Pan and Schaubel (2008) - selection modeling in hazard context
- Mortgage Default
  - Classic Option Theoretic View – Foster and van Order (1984), Kau, Keenan, and Kim (1994), Vandell (1995)
  - Dual Trigger – Elmer and Seelig (1999), Elul et al (2010), Campbell and Cocco (2011)

# Data Description

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- Random subsample of 508,758 Freddie Mac HARP refinances
  - Traits of refinance mortgage and prior mortgage
  - Performance of refinance mortgage following refinance (7.02 million loan-months)
  - Average performance history of HARP 1 loan is 32 months and 10 months for HARP 2
- Restrictions
  - Borrowers refinancing from fixed-rate 30-year mortgages to fixed-rate 30-year mortgages to rule out selection issues related to product and term
  - Experience reductions in monthly P&I payment
- Macroeconomic controls
  - BLS County-level unemployment
  - Local house price trends measured by zip-level Freddie Mac Weighted Repeat Sales Index (WRSI)

# HARP 1 Summary Statistics

**Table 1a: HARP 1 Summary Statistics**

	Mean	S.D.	P25	P50	P75
Post FICO	735	55	703	746	777
Pre FICO	729	50	695	737	769
Post Note Rate	4.968%	0.423%	4.625%	4.990%	5.250%
Pre Note Rate	6.166%	0.532%	5.875%	6.250%	6.500%
Post LTV	95%	11%	87%	93%	102%
Pre LTV	79%	10%	75%	80%	80%
Post UPB	\$223,266	\$92,830	\$149,400	\$210,966	\$288,110
Pre UPB	\$232,716	\$95,904	\$156,000	\$220,000	\$300,000
Post P&I	\$1,198	\$500	\$803	\$1,131	\$1,543
Pre P&I	\$1,410	\$569	\$960	\$1,336	\$1,808
Payment Reduction	15%	6%	12%	15%	19%
CLTV	90%	14%	81%	89%	98%
2-Year HPA	-5.9%	4.3%	-8.1%	-5.3%	-3.0%

# HARP 2 Summary Statistics (LTV ≤ 125%)

**Table 1b: HARP 2 (LTV ≤ 125%) Summary Statistics**

	Mean	S.D.	P25	P50	P75
Post FICO	729	59	693	741	777
Pre FICO	725	52	689	732	767
Post Note Rate	4.171%	0.349%	3.875%	4.125%	4.375%
Pre Note Rate	6.024%	0.589%	5.750%	6.000%	6.375%
Post LTV	100%	12%	89%	98%	109%
Pre LTV	79%	11%	75%	80%	84%
Post UPB	\$197,219	\$86,524	\$130,025	\$181,800	\$252,575
Pre UPB	\$211,997	\$91,606	\$140,000	\$196,200	\$272,000
Post P&I	\$970	\$425	\$641	\$892	\$1,240
Pre P&I	\$1,260	\$529	\$851	\$1,169	\$1,600
Payment Reduction	23%	7%	19%	24%	28%
CLTV	96%	14%	86%	95%	106%
2-Year HPA	0.4%	5.1%	-3.0%	-0.3%	2.9%

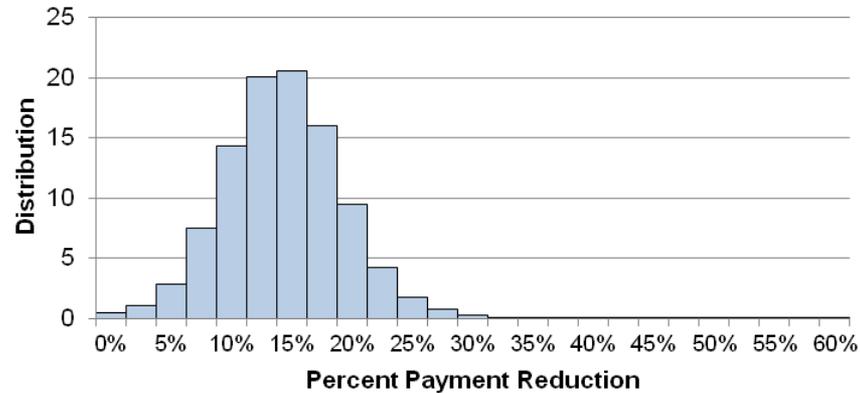
# HARP 2 Summary Statistics (LTV > 125%)

**Table 1c: HARP 2 (LTV > 125%) Summary Statistics**

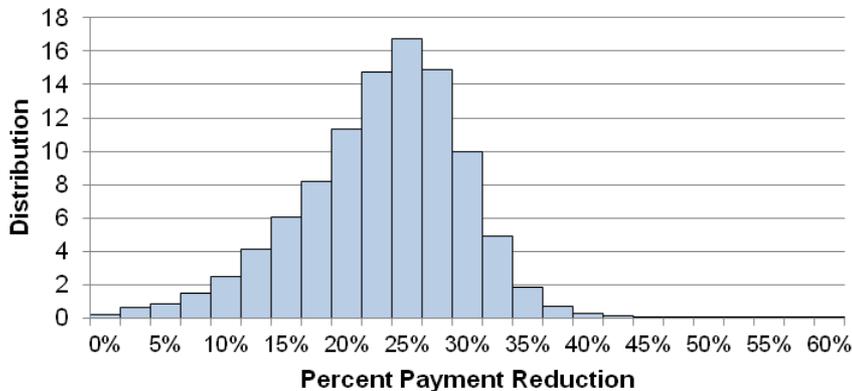
	Mean	S.D.	P25	P50	P75
Post FICO	728	58	693	739	774
Pre FICO	720	52	684	725	762
Post Note Rate	4.377%	0.350%	4.125%	4.375%	4.625%
Pre Note Rate	6.282%	0.477%	5.875%	6.250%	6.625%
Post LTV	156%	34%	135%	147%	167%
Pre LTV	81%	11%	76%	80%	90%
Post UPB	\$199,885	\$79,906	\$138,296	\$187,200	\$251,700
Pre UPB	\$213,906	\$84,592	\$148,200	\$200,000	\$270,000
Post P&I	\$1,005	\$404	\$694	\$941	\$1,267
Pre P&I	\$1,305	\$507	\$914	\$1,228	\$1,633
Payment Reduction	23%	6%	20%	24%	27%
CLTV	144%	34%	124%	137%	155%
2-Year HPA	1.0%	5.6%	-3.1%	0.3%	4.3%

# Distribution of Payment Reduction

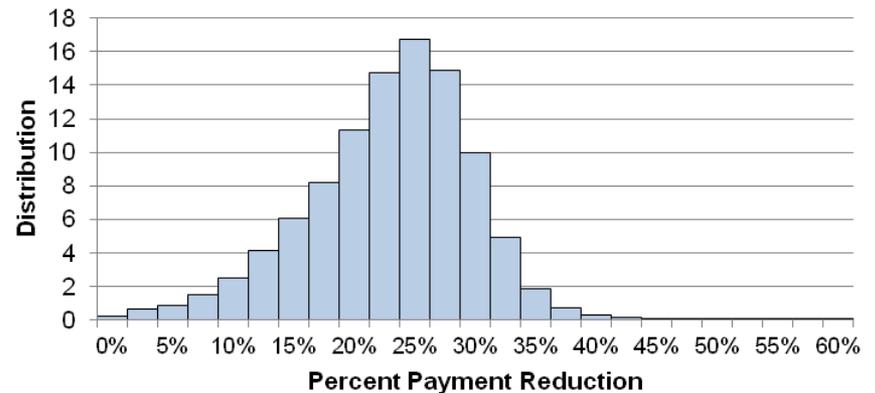
**Figure 1a: Distribution of Payment Reduction in HARP 1**



**Figure 1b: Distribution of Payment Reduction in HARP 2 (LTV ≤ 125%)**



**Figure 1c: Distribution of Payment Reduction in HARP 2 (LTV > 125%)**



# Average Default Rate Declines with Payment Reduction

**Table 2a: HARP 1 Average Ever D90+ Rates**

Post FICO	Average D90+ Rate	Post LTV	Average D90+ Rate	Payment Reduction	Average D90+ Rate
below 650	9.1%	80-90%	2.6%	0-10%	3.9%
650-700	5.4%	90-100%	3.3%	10%-15%	3.8%
701-750	3.3%	100%-110%	4.1%	15%-20%	3.0%
above 750	1.6%	110%-125%	4.3%	above 20%	2.0%

**Table 2b: HARP 2 (LTV <= 125%) Average Ever D90+ Rates**

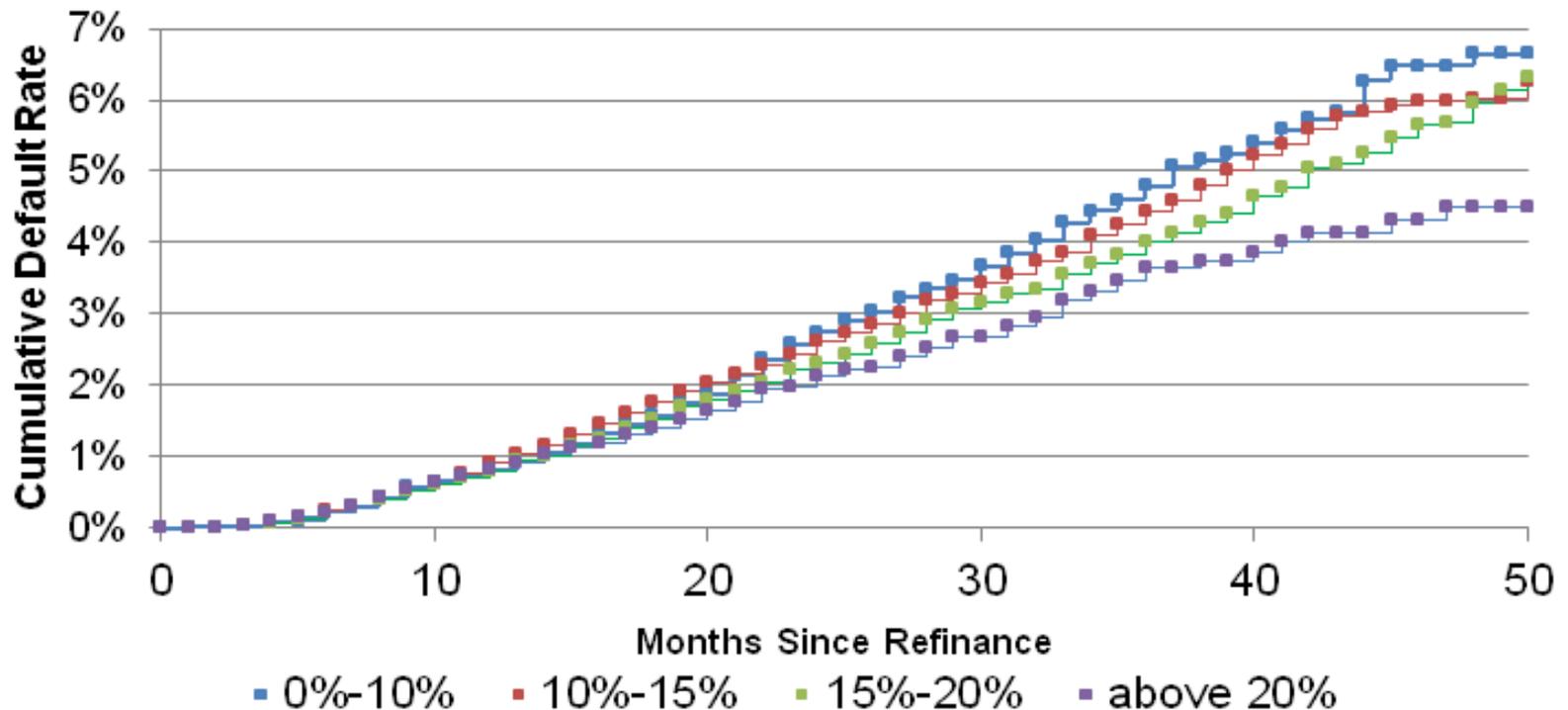
Post FICO	Average D90+ Rate	Post LTV	Average D90+ Rate	Payment Reduction	Average D90+ Rate
below 650	1.1%	80-90%	0.2%	0-10%	0.5%
650-700	0.5%	90-100%	0.3%	10%-15%	0.4%
701-750	0.3%	100%-110%	0.4%	15%-20%	0.5%
above 750	0.2%	110%-125%	0.6%	above 20%	0.3%

**Table 2c: HARP 2 (LTV > 125%) Average Ever D90+ Rates**

Post FICO	Average D90+ Rate	Payment Reduction	Average D90+ Rate
below 650	1.7%	0-10%	1.3%
650-700	1.2%	10%-15%	1.4%
701-750	1.0%	15%-20%	1.4%
above 750	0.7%	above 20%	0.9%

# KS Failure Plots Show Strong Effect of Payment Reduction on Default

Figure 2: HARP 1: Kaplan-Meier Failure Estimates by Payment Reduction



- Analysis of KM failure estimates at 46 month horizon suggest a 7.5% reduction in payment leads to about a 7.8% reduction in cumulative default rate
  - Scales to 10% reduction in default leads to 10.4% reduction in cumulative default

# Hazard Model Approach: Cox Relative Risk Model with Time-Varying Covariates

- Instantaneous probability of default described by a hazard function

$$h(t) = \lim_{\tau \rightarrow 0} \frac{P(t \leq T < t + \tau | T \geq t)}{\tau}$$

- Hazard function modeled as

$$h(t; x_{it}) = h_0(t) \exp[\beta' x_{it}]$$

- $x_{it}$  is a vector of (possibly time-varying) covariates
    - Static traits of refinance mortgage and prior mortgage
    - Time-varying covariates: Current LTV following refinance, BLS unemployment rate, house price growth rate in prior 2 years
  - $h_0(t)$  is an arbitrary baseline hazard function
- Default is defined as the first time a loan becomes more than three months' delinquent (abbreviated D90+)

# Hazard Model Estimates: Basic Specification

**Table 3: Hazard Model Regression Results (Hazard Ratios)**

	HARP 1		HARP 2 (LTV ≤ 125%)		HARP 2 (LTV > 125%)	
	(1)	(2)	(3)	(4)	(5)	(6)
Payment Reduction*10 (%)	0.898**	0.902**	0.818***	0.823***	0.776***	0.779***
Post LTV	0.985***	0.98***	0.992	0.991	1.022***	1.022***
Delta LTV	0.999	0.999	1	1	0.981***	0.981***
Post FICO	0.991***	0.991***	0.989***	0.989***	0.994***	0.994***
Delta FICO	1.001	1.001	1	1	1	1
CLTV	1.038***	1.042***	1.034***	1.035***	1.003*	1.003*
2-Year HPA	0.271**	0.314*	0.002***	0.002***	0.04***	0.049***
Unemployment Rate	1.003	1.004	1.01	1.009	1.025*	1.025
State Fixed Effects (FE) or Strata	FE	Strata	FE	Strata	FE	Strata
Vintage Fixed Effects (FE) or Strata	FE	Strata	FE	Strata	FE	Strata
-2 Log L (Intercept Only)	52,808	37,579	34,131	27,417	22,052	17,455
-2 Log L (Int + Covariates)	51,412	36,326	32,932	26,323	21,788	17,212

- Hazard ratio is  $e^{\hat{\beta}}$
- Interpretation for continuous variable: hazard ratio - 1 = semi-elasticity
  - E.g. in Model (1), 10% reduction in payment corresponds to 10.2% reduction in monthly default hazard

# Limited Evidence of Interaction Between Payment Reduction and LTV, FICO

- Interaction interpretation: Product of hazard ratios
  - E.g. equation (3): if LTV = 1.0 (e.g.100%), then hazard ratio of payment reduction effect is  $2.387 \times (0.357^{1.0}) = 0.85$

**Table 4: Hazard Model Regression Results (Hazard Ratios)**

	HARP 1		HARP 2 (LTV ≤ 125%)		HARP 2 (LTV > 125%)	
	(1)	(2)	(3)	(4)	(5)	(6)
Payment Reduction*10 (%)	2.734*	2.698*	2.387*	2.476*	0.603	0.613
LTV*Payment Reduction	0.533	0.538	0.357***	0.353***	1.023	1.014
FICO*Payment Reduction	0.999	0.999	1	1	1	1
Post LTV	0.994	0.989	1.013	1.012	1.021***	1.021***
Delta LTV	0.999	0.999	1	1.001	0.981***	0.981***
Post FICO	0.992***	0.992***	0.989***	0.99***	0.994***	0.994***
Delta FICO	1.001	1.001	1	1	1	1
CLTV	1.037***	1.042***	1.034***	1.035***	1.003*	1.003*
2-Year HPA	0.277**	0.32*	0.002***	0.003***	0.04***	0.049***
Unemployment Rate	1.004	1.004	1.01	1.01	1.025*	1.025
State Fixed Effects (FE) or Strata	FE	Strata	FE	Strata	FE	Strata
Vintage Fixed Effects (FE) or Strata	FE	Strata	FE	Strata	FE	Strata
-2 Log L (Intercept Only)	52,808	37,579	34,131	27,417	22,052	17,455
-2 Log L (Int + Covariates)	51,408	36,322	32,922	26,313	21,788	17,211

# Selection Model Detail and Motivation

- Issue: What if observed effect of payment reduction on default is biased by which borrowers select to participate in HARP program?
- Solution: Inverse Probability Weighting
  - Construct sample of HARP and eligible non-HARP loans
    - 743,725 non-HARP loans and 508,758 HARP loans
  - First stage: Logistic model with dependent variable of HARP participation
  - Second stage: Re-estimate hazard model weighting observations by inverse of estimated probability of HARP participation from first stage-model
- Pan and Schaubel (2008) show such an approach leads to unbiased estimation in context of Cox hazard model under certain conditions

# Selection Model Estimates of HARP Participation: UPB, Servicer Key Drivers

**Table 5a: Logit Model Parameter Estimates from Selection Model**

	2009	2010	2011	2012
CLTV	-0.057***	-0.059***	-0.028***	-0.013***
CLTV (Spline 100)	0.105***	0.098***	0.08***	0.045***
CLTV (Spline 125)				-0.035***
UPB	1.20***	1.30***	1.20***	1.20***
UPB Spline \$200k	-0.92***	-0.98***	-0.89***	-0.94***
FICO	-0.0001*	0.0011***	0.0009***	0.0023***
-2 Log L (Int Only)	655,747	1,232,730	928,274	1,662,234
-2 Log L (Int + Covariates)	557,148	1,046,005	804,838	1,467,748

Sum spline terms for 'slope' in interval

**Table 5b: Type III Analysis (Wald  $\chi^2$ )**

	2009	2010	2011	2012
CLTV	9,924	21,714	3,281	1,321
CLTV (Spline 100)	8,697	15,563	8,756	5,571
CLTV (Spline 125)				5,752
UPB	13,509	29,581	20,764	43,664
UPB Spline \$200k	4,073	8,687	5,499	11,697
FICO	3	409	208	3,290
Servicer Fixed Effects	32,754	56,589	50,562	77,335
State Fixed Effects	6,466	10,570	3,116	4,701

# Hazard Ratio Estimates Controlling for Selection

**Table 6: Hazard Model Regression Results (IPW) (Hazard Ratios)**

	HARP 1		HARP 2 (LTV ≤ 125%)		HARP 2 (LTV > 125%)	
	(1)	(2)	(3)	(4)	(5)	(6)
Payment Reduction*10 (%)	0.879***	0.886***	0.898**	0.875***	0.872**	0.853**
Post LTV	0.983***	0.971***	0.994	0.998	1.026***	1.026***
Delta LTV	0.998	0.999	1	1	0.979***	0.979***
Post FICO	0.99***	0.991***	0.989***	0.989***	0.996***	0.996***
Delta FICO	1.001**	1.001*	1	1	1	1
CLTV	1.039***	1.049***	1.031***	1.028***	1.001	1.001
2-Year HPA	1.288	1.042	0.001***	0.001***	0.105*	0.058**
Unemployment Rate	0.984	0.981*	1.005	1.005	1.04**	1.027
State Fixed Effects or Strata	FE	Strata	FE	Strata	FE	Strata
Vintage Fixed Effects or Strata	FE	Strata	FE	Strata	FE	Strata
-2 Log L (Intercept Only)	48,644	35,035	25,896	20,900	14,073	11,408
-2 Log L (Int + Covariates)	47,239	33,828	25,034	20,118	13,912	11,262

- Hazard ratio is  $e^{\hat{\beta}}$
- Interpretation for continuous variable: hazard ratio - 1 = semi-elasticity
  - E.g. in Model (1), 10% reduction in payment corresponds to 12.1% reduction in monthly default hazard

# Limited Evidence of Interaction Between Payment Reduction and LTV, FICO (IPW)

- Interaction interpretation: Product of hazard ratios
  - E.g. equation (3): if LTV = 1.0 (e.g.100%), then hazard ratio of payment reduction effect is  $2.801 \times (0.429^{1.0}) = 0.85$

**Table 7: Hazard Model Regression Results (IPW) (Hazard Ratios)**

	HARP 1		HARP 2 (LTV ≤ 125%)		HARP 2 (LTV > 125%)	
	(1)	(2)	(3)	(4)	(5)	(6)
Payment Reduction*10 (%)	3.231*	3.434**	2.801*	2.935*	0.329	0.512
LTV*Payment	0.626	0.631	0.429**	0.421**	1.346***	1.278***
FICO*Payment	0.999**	0.999**	1	1	1.001	1
Post LTV	0.99	0.977***	1.012	1.016	1.02***	1.021***
Delta LTV	0.998	0.999	1	1	0.979***	0.979***
Post FICO	0.992***	0.992***	0.99***	0.99***	0.994**	0.996*
Delta FICO	1.001*	1.001*	1	1	1	1
CLTV	1.039***	1.049***	1.031***	1.028***	1	1.001
2-Year HPA	1.326	1.074	0.001***	0.001***	0.1*	0.056**
Unemployment Rate	0.985	0.981	1.005	1.006	1.04**	1.027
State Fixed Effects or Strata	FE	Strata	FE	Strata	FE	Strata
Vintage Fixed Effects or Strata	FE	Strata	FE	Strata	FE	Strata
-2 Log L (Intercept Only)	48,644	35,035	25,896	20,900	14,073	11,408
-2 Log L (Int + Covariates)	47,235	33,823	25,029	20,112	13,902	11,256

# Quantitatively Similar Estimates of Payment Reduction Effect as Other Authors

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- Fuster and Willen (2012): Cutting payment in half reduces default hazard by about two thirds
  - Examine interest-only (IO) mortgages
- Tracy and Wright (2012): 10% payment reduction leads to 22.5% reduction in monthly default hazard for borrowers with CLTV above 80%
  - Sample: Downward resets for adjustable rate mortgages (ARMs)
  - Observe relatively small magnitudes of payment change relative to HARP

# Conclusion

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- Finding: 10% reduction in monthly payments leads to about a 10%-12% reduction in monthly default hazard
- Result holds when controlling for selection based on observables
- Contributions:
  - Extends other research on smaller market segments to mainstream fixed-rate 30-year mortgage market
  - Controls for selection based on observables using novel approach from biostatistics literature